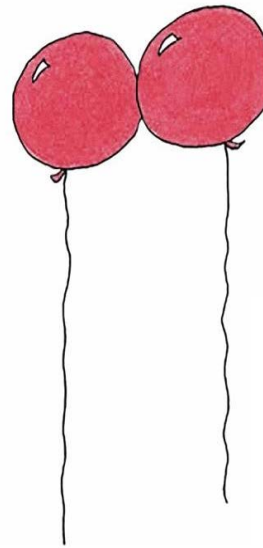


Science 9

UNIT 3 : PHYSICS



"You're calling it love, but it's really just static electricity."

BOOK 2: HOW DO ELECTRIC CHARGES BEHAVE?

name: _____

block: _____

PART A ELECTRONS CARRY A NEGATIVE CHARGE, AND PROTONS CARRY A POSITIVE CHARGE.

Rub two different materials together. Depending on the materials you use, something may come off one and transfer to the other, and the two materials will _____. About 250 years ago, American scientist Benjamin Franklin used the term _____ to describe the "somethings" rubbed off a material. He said that an excess of _____ were left behind.

Today we know the negative charges are the charges of _____, and the positive charges are the charges of _____.

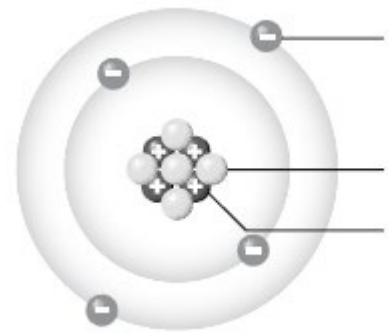
Protons are part of the _____ of atoms and are held firmly in place, so they cannot be rubbed off materials.

Electrons can be rubbed off, because they _____ the nucleus and some are _____ to it.

Recall that all matter is made of tiny particles called atoms.

At the centre of the atom is the _____, which contains particles called neutrons and protons.

_____ do not have a charge. _____ have a positive charge, so the nucleus is _____ charged.



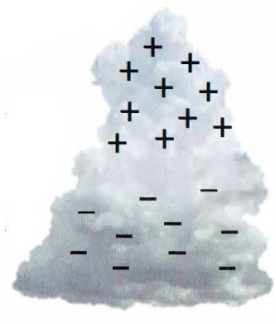
Around the positive nucleus are much lighter particles called _____ that have a negative charge.

If the number of positive charges equals the number of negative charges, the atom is _____.

When electrons are rubbed off a material, it becomes _____ charged. The material that gains electrons becomes _____ charged.

Charging a material by rubbing is called _____. Whether a material gains or loses electrons depends on the combination of materials.

For example: Clouds may be charged by friction in a thunderstorm.



Clouds in storms can become **charged by friction**. Warm, moist air causes strong updrafts in the clouds. At the same time, hail and ice crystals fall from the top, causing downdrafts. As droplets and crystals _____, electrons are stripped from upward-moving particles and are carried downward. As a result, clouds are **negatively charged** at the _____ and **positively charged** at the _____.

In order to study static charge in lightning and in other phenomena, scientists needed a device that could produce large amounts of _____ in the **laboratory**.

The first successful “lightning” machine was invented in _____ by American physicist Robert Van de Graaff. The _____ uses _____ to produce a large static charge on a metal dome. A moving belt produces a static charge at the base of the generator. The belt carries this charge to the top where it collects on the dome.



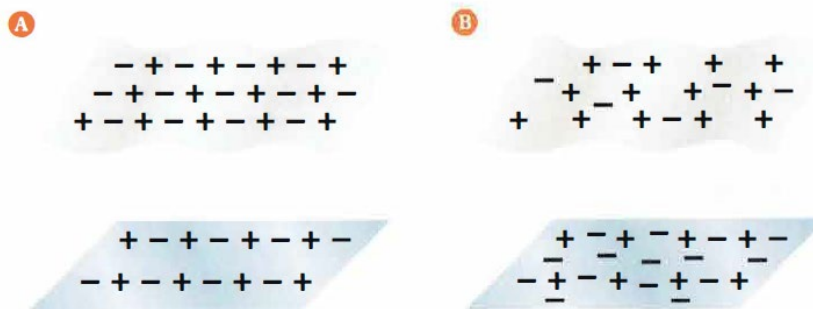
Figure 7.5 Charge is transferred onto a moving belt at the base of the generator, position A, and is transferred off the belt onto the metal dome, position B.



How do you think lightening forms?

ELECTRICALLY NEUTRAL AND ELECTRICALLY CHARGED MATERIALS

- _____ **Materials:** Before two materials are rubbed together, they have _____ numbers of positively charged protons and negatively charged electrons. Because the equal numbers of positive and negative charges cancel each other out, the materials are _____.
- _____ **Materials:** If _____ are rubbed off one material, the protons _____ and the material becomes electrically charged. So does the material that gains the electrons. A material or object that is electrically charged has an _____ number of positive and negative charges.



A) This diagram shows a paper towel (top) and an acetate strip (bottom) before they are rubbed together.

B) This diagram shows the two materials after they are rubbed together.



Assignment #1: Worksheet Q #1-7

Complete this assignment in the space provided below.

1. The atom consists of three smaller particles.
 - (a) Give the name and charge of each of these particles.
 - (b) State where in the atom each of the three particles is found.
2. Explain the relationship among negative charges, positive charges, electrons, and protons.
3. When is an atom uncharged or neutral?
4. How are solid materials charged?
5. What is the overall charge when an atom has more protons than electrons?
6. What happens to the charge on an atom when it gains electrons?
7. What can happen to electrons during friction? Describe what sometimes happens in terms of charges when you rub two different types of materials together.

STOP

Examples:

INSULATORS

Conductors are materials that _____ the flow of _____ or _____ from atom to _____ or from _____ to molecule.

Conductors are used when the _____ of _____ or electricity is desirable.

Insulators are materials that _____ the flow of _____ or _____ from atom to _____ or molecule to _____. Insulators are used to _____ against the dangerous effects of _____ or _____ flowing in a _____.

Examples:

GO

CONDUCTORS

INSULATORS & CONDUCTORS

If you held a _____ plastic rod in the middle and rubbed just one end of the rod with a paper towel, the end you rubbed would become _____. The other end of the plastic rod would _____.

The _____ you added to the neutral plastic by **friction** will _____.

- Materials that **DO NOT** allow _____ easily are called **electrical** _____.

- Electrons r_____ from one location on an insulator are **not replaced** by electrons from another location.

- EXAMPLES:** _____



Fig 7.4A Charges on insulator

- Materials that _____ **electrons to travel freely** are called electrical _____.

- If a charged acetate strip is touched to one end of a metal rod, the _____ on the acetate will **spread evenly** over the entire length of the rod.

- M_____ are **GOOD** conductors because the atoms in metals have *at least one* _____ that is _____.

- These electrons are sometimes called "_____" because they are free to move throughout the conductor.

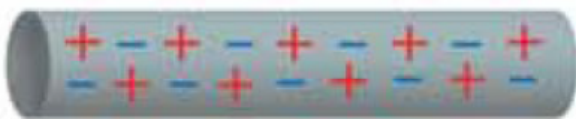


Fig 7.4B Charges on conductor

Since **static electricity** is charge that is held _____ in one place, **only** _____ can retain a static charge.
_____ such as copper and aluminum **allow** _____.



READING ABOUT: STATIC CHARGE PG 7-8

Complete the following reading about static electricity and charge on materials. Be sure to "Mark the Text" and highlight KEY DEFINITIONS as you read along.

ALSO, answer the "Reading Check" questions in the side margin as you go! ✓

Before You Read

Why do you get a shock when you walk across a carpet in wool socks and then touch a metal door handle? Record your thoughts on the lines below.



Mark the Text

Identify Concepts

Highlight each question head in this section. Then use a different colour to highlight the answers to the questions.



Reading Check

1. Name the two types of charged particles in an atom.

What is static charge?

When materials are rubbed together, you might see them cling to each other or move away from each other. Materials that behave in this way are said to carry an electric charge. When a charge stays in place for some length of time, it is described as static electricity or **static charge**.

Why does rubbing make materials charged?

Recall that all matter is made up of atoms. Most of the mass of an atom is in its nucleus—its central core region. The nucleus is made up of two types of particles. Protons are particles that have a positive (+) charge. Neutrons are particles that do not have a charge so they are neutral. The space around the nucleus contains fast-moving particles called electrons. Electrons have a negative (−) charge.

The overall charge of a material depends on the balance between the positive and negative charges in all the atoms of the material. A material may be neutral, have a positive charge, or have a negative charge.

When two materials are rubbed, electrons from the atoms of one material may move to the atoms of the other material. The movement of electrons from one atom to another changes the charge on the atoms. When an atom loses electrons, it is left with more protons than electrons, so its charge is positive. When an atom gains electrons, it has more electrons than protons, so its charge is negative. ✓

Charges in a material that is neutral (uncharged)	Charges in a material that is positively charged	Charges in a material that is negatively charged
$++-+--$ $--+-++$	$+++++-$ $--++++$	$---+-+$ $---+-+$
equal protons and electrons	more protons than electrons	more electrons than protons

How else can charges be produced?

You already know that charges can be produced by rubbing (friction). This can happen in nature when air rubs against ice crystals and dust particles in clouds, producing lightning. Scientists also use a friction-producing machine called a **Van de Graaff generator** to create charges that they can study.

How easily do charges move in different materials?

Electrons cannot move easily in materials such as **acetate** (a type of plastic), rubber, wool, and glass. Materials that do not let electrons move through them easily are called **insulators**. Charges tend to build up on insulators.

Electrons can move easily through materials such as metals. Materials that let electrons move through them easily are called **conductors**. Sometimes, a conductor is used to transfer static charges from an object to the ground. Allowing charge to flow into Earth's surface is called **grounding**. ✓

How are charges measured?

Electric charges are measured in units called **coulombs** (C). A bright light bulb, for example, allows about 1 C (one coulomb) of electric charge to pass through it each second.



Charges on insulator



Charges on conductor

✓ Reading Check

2. What does a conductor allow to move easily through it?



Charge it

Vocabulary

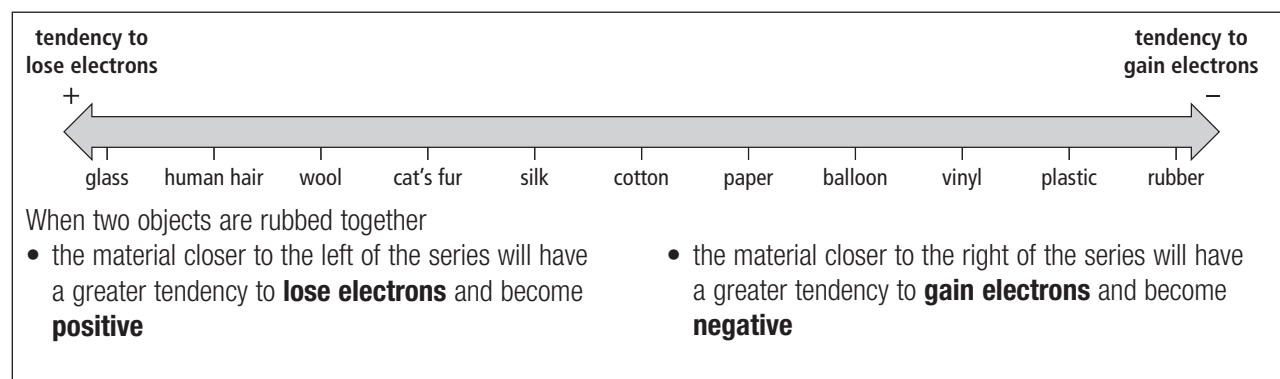
acetate	negative
atoms	neutral
conductors	neutrons
coulomb	nucleus
electric	positive
electrons	protons
grounding	static charge
insulators	Van de Graaff generator

Use the terms in the vocabulary box to fill in the blanks. You may use terms more than once. You will not need to use every term.

1. Static electricity is also known as _____.
This refers to the build-up of electric charge in one place.
2. All matter is made of tiny particles called _____.
3. The positively charged _____ is the centre of the atom.
It consists of positively charged subatomic particles called _____
and subatomic particles with no charge called _____.
4. The negatively charged subatomic particles called _____
occupy the area around the nucleus.
5. An object is uncharged or _____ when the number of
positive charges equals the number of negative charges.
6. If an atom loses an electron, it has more protons than electrons. This atom will have
an overall _____ charge.
7. If an atom gains an electron, it has more electrons than protons. This atom will have
an overall _____ charge.
8. Glass and acetate are examples of _____ because they
do not allow electrons to move easily through them. Metals like copper and aluminum
are good _____ because they allow electrons
to move freely through them.
9. The _____ is a unit of electric charge.
10. Scientists use a(n) _____ to create static charge.
11. Lightning rods on top of buildings allow static charges from lightning to flow into
Earth's surface. This is known as _____.

Static charge detective

Use the following diagram to answer the questions.



1. As you take your clothes out of the dryer, your wool socks are clinging to your silk skirt. What is the charge on the wool socks and on the silk skirt?

Charge on socks

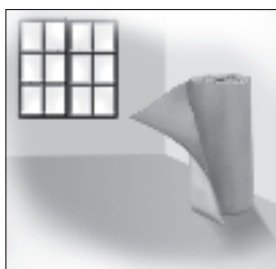
Charge on skirt

2. You use a plastic comb to comb your hair. What is the charge on your hair and on the comb?

Charge on comb

Charge on hair

3. You use a paper towel to rub off some dirt on a glass window. What is the charge on the glass and on the paper towel?



Charge on window

Charge on paper towel

4. You rub a balloon along your cat's back, causing the cat's fur to stand up. What is the charge on the balloon and on the cat's fur?



Charge on balloon

Charge on cat's fur

Conductors and insulators

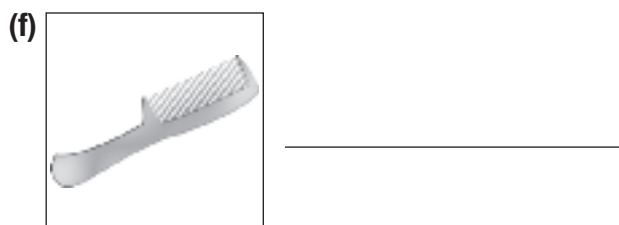
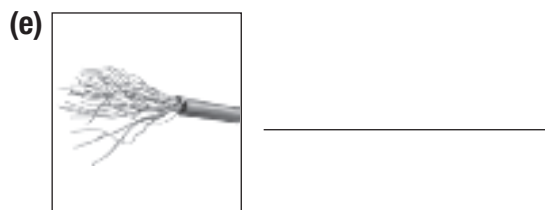
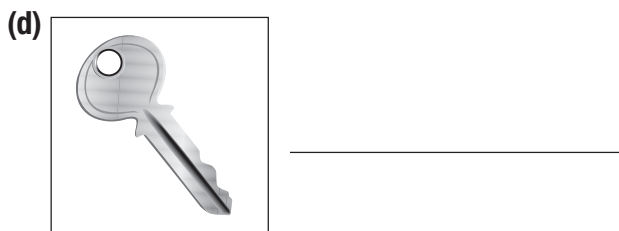
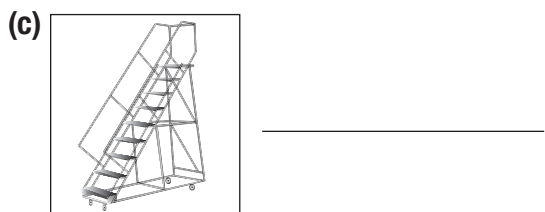
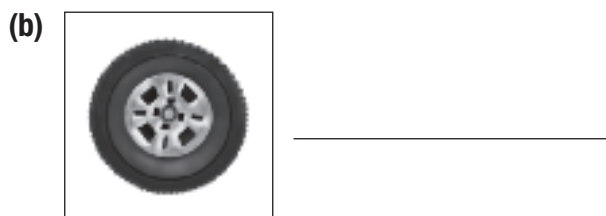
Define and identify conductors and insulators as directed below.

1. Define the following terms.

(a) conductor _____

(b) insulator _____

2. On the first line, indicate whether the object is a conductor or an insulator. On the second line, state whether or not the material allows electrons to move freely.



PART B: OPPOSITE CHARGES ATTRACT EACH OTHER, AND LIKE CHARGES REPEL EACH OTHER.

Long before scientists knew what positive charges and negative charges were, they knew how charges interacted with each other.

Two important properties of charges are summarized in the **law of electric charge**:

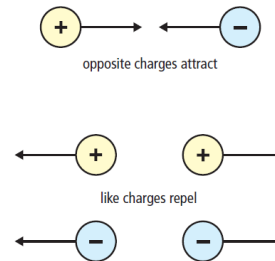
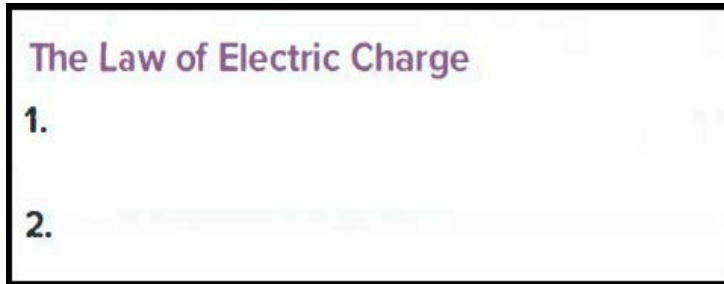


Figure 7.10 Positive and negative charges exert forces on each other.

The **law of electric charge** applies to all individual charges.

This means that a negative charge does not **JUST attract** another positive charge....BUT ALSO....

- ✓ every negative charge attracts _____
- ✓ every negative charge _____ every other negative charge
- ✓ every positive charge repels _____

When you bring together objects that have an excess of either positive charges or negative charges, you see the overall result of all these different attraction and repulsions.

ATTRACTION BETWEEN CHARGED OBJECTS AND NEUTRAL OBJECTS

The law of electric charge explains why **charged objects** _____ **neutral objects** (Figure 3.11).

All neutral objects have an _____ number of **protons and electrons**.

Therefore, they have an equal number of **positive and negative** _____.

When you bring a charged object near a neutral object, the _____

in the neutral object _____.

Instead, the positive and negative charges in the molecules of the object
_____ from each other.

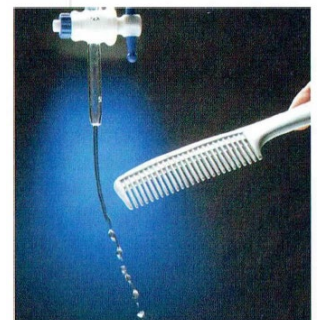


Figure 3.11 In this photo, the comb is charged, and the water is neutral.

LAB ACTIVITY

LAB SIMULATION: <https://phet.colorado.edu/en/simulation/balloons-and-static-electricity>

Figure 3.12 This diagram shows why a charged balloon sticks to an electrically neutral wall.

The negative charges in the wall are pushed away from the surface by the negative charges on the balloon. Then the positive ends of the molecules in the wall are attracted to the negative charges on the balloon. These forces of attraction are strong enough to hold the balloon to the wall.

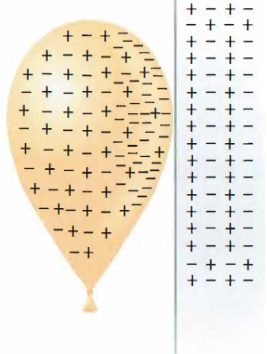


Figure 3.12 shows what happens to a neutral wall when a charged balloon comes close to it.

The _____ charges in the wall are pushed _____ from the surface by the negative charges on the balloon.

Then the _____ ends of the molecules in the wall are _____ to the negative charges on the balloon.

These forces of attraction are strong enough to hold the balloon to the wall.



1. State the law of electric charge.
2. Refer to Figures 3.11 and 3.12. Make a labelled sketch, including charges, to explain why a stream of neutral water bends toward a positively charged comb.

PART C: ELECTRIC FORCE



_____ is defined as a push or a pull.

When something is _____ that is being moved, it is an example of _____ **forces**, which are forces that can have an effect only on objects that they _____

The **amount** of electric force depends on the **amount of charge** on each object and the distance separating the objects. **Increasing** the amount of charge **increases the electric force**.

Suppose you bring a charged comb near small pieces of paper. **Without** making contact, the paper will be _____ to the comb.

An electric force is a push or pull between _____ objects. The electric force is an example of _____ forces, which can apply force to an object _____.



Figure 7.9 Even though the comb is not touching the paper on the table, the paper is attracted to the charged comb.

CHARGING BY CONDUCTION



Figure 7.11 A negatively charged rod adds extra electrons to the electroscope.

When a negative object is touched to a neutral electroscope, _____ are added to the electroscope. These extra electrons _____ evenly over the entire metal surface of the electroscope leaves .

Since _____ metal leaves now have a negative charge, they _____.

Charging a _____ object _____ *it to a charged object* is called **charging by** _____.

Touching the neutral electroscope with a positively charged object would have the same result. Electrons from the metal in the electroscope would be **attracted** to the positive object. Therefore, the metal leaves would both become positively charged after _____ to the positive object.

CHARGING BY INDUCTION

The leaves of a neutral electroscope can be made to separate even if the knob is not touched with a charged object.

If you bring a negatively charged object _____ **but not touching**, the knob of the electroscope, the negative charge will _____ the electrons in the knob. The **electroscope is a conductor**, so the _____ will _____ **to the leaves**

The leaves of the electroscope will have a **temporary negative charge** and will _____ each other. The knob will be positively charged.

This is called _____. When an object is charged by induction, **no electrons are actually transferred** from one object to the other. Instead, inducing a charge _____ electrons inside the object. If you move the charged object away, the leaves will *go back to their original position*.

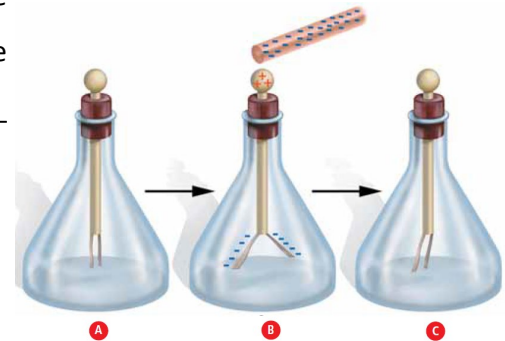
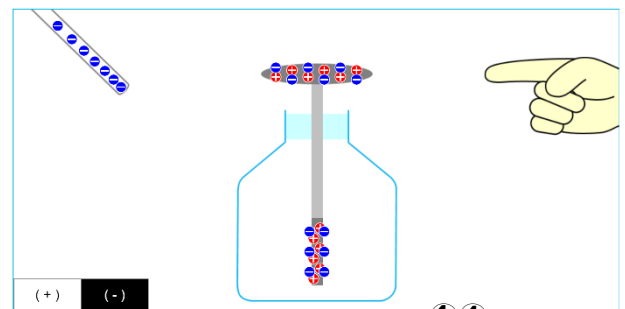


Figure 7.12 In a neutral electroscope, the leaves are not separated (A). When a negative object is brought close to the positive knob, electrons in the knob are pushed down to the leaves, causing the leaves to separate (B). When the negative object is removed, the leaves return to their original position because no charge was transferred between the object and the electroscope (C). The charges simply moved or separated.

ELECTROSCOPE LAB SIMULATION: https://javalab.org/en/electroscope_en/

Table #1: Electroscope Induction

+ Charged Rod	- Charged Rod



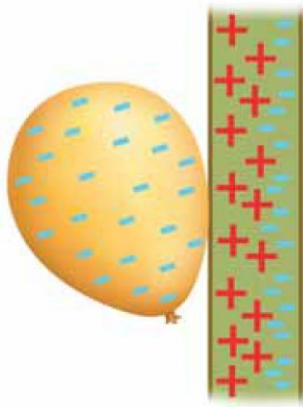


Figure 7.13 A charged balloon sticks to the wall because a positive charge is induced on the surface of the wall.

REVISIT: THE ATTRACTION OF NEUTRAL OBJECTS

Induction explains why neutral objects and charged objects **attract** each other.

For example, when you rub a balloon in your hair, the balloon becomes _____ charged. Since the balloon is an _____, the negative charge remains in a *nearly* _____ on the balloon.

If you place the charged balloon against the wall, the negative charges in the wall are _____ from the balloon.

The part of the wall closest to the balloon now has a _____ charge because the electrons in that region are **repelled due to induction**. The negative charge on the balloon will be _____ to the positive wall, and therefore the balloon will _____ to the wall.



1. What is the definition of an electric force?
2. Explain what is meant by action-at-a-distance force.
3. According to the laws of static charge, explain how:
 - (a) like charges react
 - (b) opposite charges react
 - (c) neutral objects react to charged objects
4. What is electric force proportional to?
5. In terms of charge transfer, what is the difference between charging by conduction and charging by induction?
6. When a charged balloon sticks to the wall, does the wall become charged by induction or conduction?



READING ABOUT: ELECTRIC FORCE PG 16-17

Complete the following reading about electric forces and their properties.
Be sure to "Mark the Text" and highlight KEY DEFINITIONS as you read along.

ALSO, answer the "Reading Check" questions in the side margin as you go! ✓

Before You Read

If you rub a balloon on a sweater it will stick to the wall. Why? Write your ideas on the lines below.

Make Flash Cards

For each paragraph, think of a question that might be on a test. Then write the question on one side of a flash card. Write the answer on the other side. Quiz yourself until you can answer all the questions.

✓ Reading Check

1. What will happen if a pen with a positive charge comes near paper with a negative charge?

What laws describe electric charges?

Electric force is a pull (attraction) or a push (repulsion) between objects that are charged. The **laws of static charge** describe what happens when charged and uncharged objects come close to each other.

The Laws of Static Charge

1. Objects with the same charge repel each other.
2. Objects with opposite charges attract each other.
3. Charged objects attract neutral objects. ✓

The electric force that acts on any pair of objects depends on:

- ◆ the type of charge on the objects (positive, negative, or neutral)
- ◆ the amount of charge on the objects
- ◆ the distance between the objects

If you increase the amount of charge on objects, you increase the electric force. If you increase the distance between objects, you decrease the electric force.

What is an electroscope?

An electroscope is a device that can be used to detect the presence of charge. A typical electroscope has one or two lightweight strips of metal that bend easily. These metal strips, called leaves, are attached to a central metal rod that has a metal sphere at the top. Sometimes, the leaves and metal rod are enclosed in glass or plastic so that air movement does not affect the device. When the leaves repel each other, you know they are charged.

What is charging by conduction?

When you charge a neutral object by touching it to a charged object, it is called **charging by conduction**. For example, if you touch a neutral electroscope with a negatively charged rod, electrons are added to the electroscope and spread over the surface of the metal leaves. The leaves then become negatively charged and repel each other.

What is charging by induction?

You do not have to touch the sphere of an electroscope to make the leaves separate. If you bring a negatively charged rod near—but not touching—the sphere, the rod will repel the electrons in the sphere. The negative charges will move down to the leaves and the leaves will repel each other. This is called **charging by induction**. The sphere will be left with a temporary positive charge. If the negatively charged rod is removed, the electrons will move back to the sphere, and the sphere will be neutral again. ✔

Why are neutral objects attracted to charged objects?

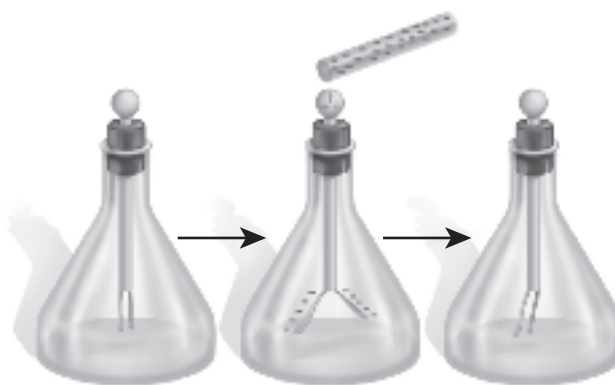
Neutral objects are attracted to charged objects because the neutral objects are temporarily charged by induction. For example, a negatively charged balloon sticks to a neutral wall because the balloon's negative charges repel the wall's negative charges. In other words, a positive charge is induced on the surface of the wall. The negative balloon is attracted to the positive wall surface.

✔ Reading Check

2. Why are neutral objects attracted to charged objects?



Charging an electroscope by conduction



Charging an electroscope by induction

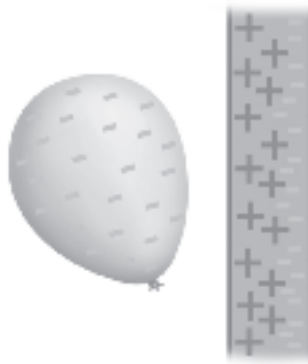
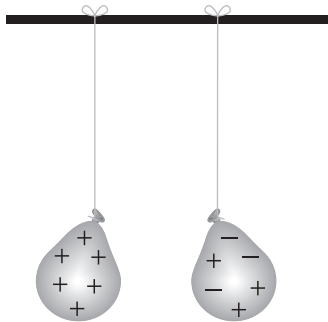
Neutral, positive, or negative charges?

Answer the questions below in the spaces provided.

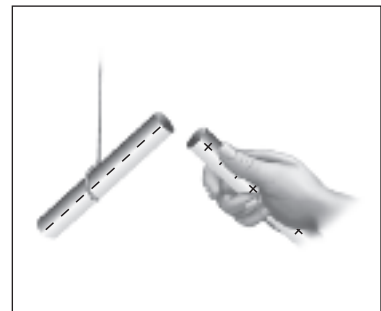
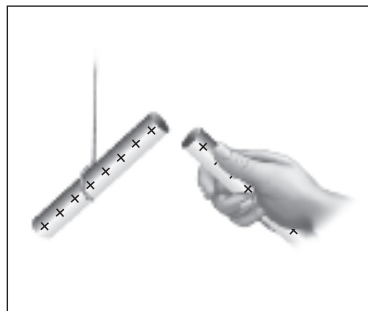
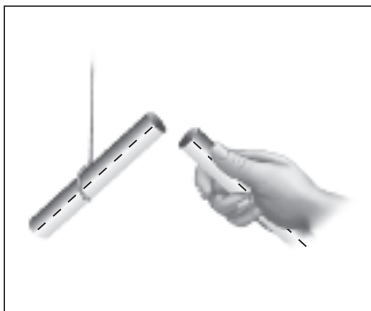
1. What are the three laws of static charge?

- (a) _____
 (b) _____
 (c) _____

2. For each situation illustrated below, will the objects shown attract or repel each other?



- (a) _____ (b) _____ (c) _____



- (d) _____ (e) _____ (f) _____

Charging by conduction or induction

Analyze the situations below. Do they describe charging by conduction or induction?

1. Identify whether the situation is describing charging by conduction or induction.

(a) You notice the build-up of dust on a computer screen when it is on.

(b) You walk across a carpet and experience a shock when you touch a metal doorknob. _____

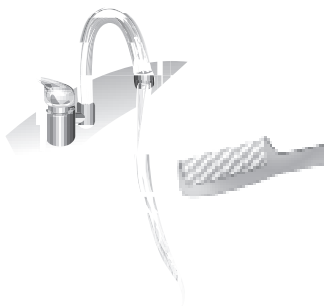
(c) You rub a balloon against your hair and bring it close to a pile of salt on the table. This causes the salt crystals to “jump up and dance.” _____

2. Identify whether the illustration shows charging by conduction or induction.

(a)



(b)



(c)



Positive, negative, and neutral objects

Vocabulary	
amount of charge	electroscope
attract	increase
conduction	induction
contact forces	laws of static charge
decrease	neutral
distance between objects	repel
electric force	type of charge

Use the terms in the vocabulary box to fill in the blanks. Each term may be used more than once. You will not need to use every term.

1. A(n) _____ is a push or pull between charged objects.
2. The _____ state that like charges _____ and opposite charges _____.
Charged objects are attracted to _____ objects.
3. The electric force that acts on any pair of objects depends on the _____ and _____ on the objects and on the _____.
4. If you increase the amount of charge on objects, you _____ the electric force. If you _____ the distance between objects, you decrease the electric force.
5. A device that can detect the presence of charge is the _____.
6. If the leaves of an electroscope become charged, they will _____ each other.
7. If a charged rod is brought close to an electroscope and then removed, the electroscope will become _____.
8. Charging by _____ occurs when objects touch and an electric charge is transferred from one object to the other.
A(n) _____ can be used to demonstrate this.
9. Charging by _____ occurs when objects are charged without touching. A(n) _____ can be used to demonstrate this.
10. Neutral objects are attracted to charged objects because they are charged by _____.